Health & Safety Technical Guidelines

HS-TG-03/1

Ionized Radiation Safety

Produced by

HSS – Facilities & GS Department

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1 Purpose

1.1.1 The purpose of this document is to protect the health and well-being of all Qatar University (**QU**) staff, students, and visitors, and to prevent damage to property, equipment, facilities, and the environment associated with the usage of radiation as part of the university's activities.

1.1.2 This document provides guidelines on the application of the requirements and principles of the QU Health & Safety Management System (**HSMS**) to activities associated with these QU workplaces.

2 Scope

2.1.1 This HS Technical Guideline applies to all operations and activities associated with QU activities where radiation is involved, such as laboratories, to enable the effective management of the associated HS aspects and risks.

2.2 Responsibilities

2.2.1 Top Management

2.2.1.1 QU top management shall allocate sufficient resources for the effective implementation of the HSMS, including the application of this HS Technical Guideline, and ensure that QU employees, students, contractors and visitors are aware of their responsibilities through appropriate regulation, delegation and communication.

2.2.1.2 The QU Top Management is also accountable for monitoring and reporting HS performance and appropriate programs and actions to ensure compliance with the QU HS Policy.

2.2.2 Other Accountabilities

2.2.2.1 The QU HS and the HS Committee are accountable to the QU Top Management for the implementation of this HS Technical Guideline.

2.2.2.2 Vices of President (VPs), , Deans, Directors, Managers, Head Sections/Units and Project Managers are accountable to the QU Top Management for the application of this HS Technical Guideline in areas under their supervision.

2.2.2.3 All QU staff is responsible for performing their duties by complying with the requirements of this HS Technical Guideline as it applies to their activities and workplaces, observing and obeying safety postings and rules, and promptly reporting all incidents and accidents to their supervisors.

3 Guidelines

3.1 General Requirements

Qatar University has been authorized by the State of Qatar's Ministry of Environment to use radiation sources in operations, education, and research and development activities. The QU Laboratory Safety Subcommittee may authorize individual faculty members, as well as authorizing other users, to use radiation sources after a review of the proposed use, adequacy of facilities, and experience of the applicant. Although this provision allows the University great flexibility in dealing with the multitude of radiation sources and research uses encountered on campus, it places equally great responsibility on investigators and the administration to comply with Qatar regulations so that this flexibility may continue.

Qatar University permits the use of radioactive materials and sources of ionizing and non-ionizing radiation while providing for their safe use. The use of radiation sources is a privilege; in order to retain the privilege, all persons who use sources of radiation must follow this Technical Guideline for their safe and legal use.

Safe use of radioactive materials and sources of ionizing radiation means more than simple adherence to the regulations and recommendations of standards-setting agencies. Current regulations reflect the viewpoint that some degree of risk may be associated with any exposure to radiation. In keeping with this regulatory position, it is incumbent on all authorized laboratory personnel, registrants, and radiation workers to keep doses to personnel and releases to the environment As Low As Reasonably Practicable (**ALARP**).

This Technical Guideline summarizes the terms of the University's authorization and the regulations most applicable to campus utilization of various radiation sources. A copy must be available for each Authorized User's facility where radiation sources are used. Special precautions, regulations, and other operating procedures specified by the Laboratory Safety Subcommittee or HS as a condition for approval of radiation source authorization must also be maintained and made available to laboratory personnel and HS inspectors.

3.2 Radiation Protection Principles

3.2.1 Types of Radiation Dose

The body may be irradiated in two general ways; externally from radioactive material or radiation sources, or internally from radioactive material ingrained in the body.

External doses can be the result of exposure to gamma, x-ray, or high-energy beta emitters. Low energy beta and alpha emitters lack the energy needed to penetrate the outer layer of skin and subsequently present less of an external hazard, and are of more concern when ingested. The radiation dose an individual receives depends on the following factors:

- Exposure*:* The "strength" (activity, mrem/hr, etc.) of the radiation source. By reducing the amount of radioactive material used or lowering the settings on a radiation-producing machine, dose can be reduced.
- Time*:* The total dose received from an external source is dependent on the amount of time of being actually exposed to the source. Therefore, any time that is spent near a source should be controlled, and used effectively.
- Distance: By increasing the distance between the source of exposure and an individual, the dose received can be significantly reduced. When an individual doubles his/her distance from a gamma source, for example, the dose rate at the further distance will drop to one-fourth of the level at the closer distance.
- Shielding: When radiation sources are being used, absorbing material or shields can be incorporated to reduce exposure levels. The specific shielding material and thickness depends on the amount and type of radiation involved.

Internal exposure results from the absorption, ingestion or inhalation of radioactive material. This material can be incorporated in the body in several ways:

- Breathing radioactive gases, vapors or dust.
- Consuming radioactive material transferred from contaminated hands, tobacco products, food, or drink.
- Entering through a wound.
- Absorption through the skin.

3.2.2 Objectives of Radiation Protection

The fundamental objectives of radiation protection measures are:

- To limit exposure from the external radiation to levels that are as low as reasonably achievable and always within the established dose limits.
- To limit entry of radionuclides into the human body via ingestion, inhalation, absorption, or through open wounds when unconfined radioactive material is handled, to quantities as low as reasonably achieved and always within the established limits.

3.3 General Guidance for Radioactive Material Use

- The procedure for each project should be well outlined in writing for all laboratory personnel. The necessary equipment, waste containers, and survey instruments must be available.
- Characteristics of the radioactive material such as type of radiation, energy, half-life, significant and typical amounts, and chemical form should be known.
- In some cases, before the procedure is actually performed with radioactive material, a "dry run" practice of the procedure may be useful to avoid problems.
- A radiation worker should supervise visitors and students in the laboratory that uses radioactive material.
- The radioactive material must not be left unattended in places where it may be handled or removed by unknowing and unauthorized persons. All lab rooms and waste storage areas must be locked when unattended.
- As a general practice, work with radioactive material should be confined to only the areas necessary. This simplifies the problem of confinement and shielding, and aids in limiting the affected area in case of an accident.
- All work surfaces and storage areas (tabletops, hoods, floors, etc.) should be properly covered. Some facilities, especially in older buildings, are very difficult to decontaminate.
- Absorbent mats or paper should be used. Protective absorbent with a plastic back and absorbent front is especially useful. If contaminated, it can simply be discarded in the radioactive waste container.
- Plastic or metal trays (stainless steel washes easily) should be placed on the surface when liquids are to be used. The tray serves to contain a spill.
- Good housekeeping must be practiced at all times. If an area is kept neat, clean, and free from equipment not required for the immediate procedure, the likelihood of accidental contamination or unnecessary exposure is reduced.
- Radioactive material, especially liquids, should be kept in unbreakable containers whenever possible. If glass is used, a secondary container must be provided.
- Never pipette by mouth suction. Always use a mechanical pipette filling device.
- Eating, drinking, smoking, application of cosmetics, or storing of food is prohibited except in specifically defined and posted food item areas
- Refrigerators used to store radioactive material shall not be used for the storage of food. All storage compartments (refrigerator and freezer sections) must be conspicuously posted with radiation warning stickers.
- Refrigerators used for food storage must be posted as "FOOD STORAGE AREA - NO HAZARDOUS SUBSTANCES ALLOWED." These appliances must be included in the monthly radiation survey.
- Smoking is not permitted in areas where work with unsealed radioactive sources is in progress or where contamination may exist. Under no circumstances should cigarettes, cigars, or pipes be left on tables or benches where radioactive work has been performed or is in progress.

- Wash hands thoroughly after working with or near radioactive materials and before eating, drinking, smoking, or applying cosmetics.
- Protective gloves must be worn any time an unsealed radiation source is being used. Do not use the telephone; handle books, open cabinets, or the like with contaminated gloves. If there is a break in the skin on the hand, be sure to wear gloves.
- Lab coats and appropriate shoes must be worn by all individuals handling radioactive material.
- All reusable glassware and tools used with radioactive material should be thoroughly cleaned after use and kept separate from non-contaminated items. It is recommended that a marked container or area be provided for glassware and tools used in radioactive work.
- Radiation workers should be accredited by the Ministry of Environment of the State of Qatar.

3.4 General Guidance for Use of Radiation Producing Equipment

- Each individual intending to operate any radiation producing machine must be trained in its use by an individual familiar with the system.
- Each individual working with a radiation machine should know exactly what work is to be done and which applicable safety precautions should be used Radiation Safety Rules.
- Written operating and safety procedures must be available to personnel before operating this type of machine.
- Visitors and students in the area of work should be supervised by the equipment operator.
- Radiation producing machines must not be left unattended in an operational mode.
- Structural shielding requirements for any new installation, or any modifications to an existing unit or room, must be approved by the HS before the machine is used.
- When the safe use of the equipment depends on the mechanical set up of the unit or on technique factors, these restrictions should be closely followed.
- Under no circumstances shall shutter mechanisms or interlocks be defeated or in any way modified except in accordance with approved written procedures.
- All warning lights should be "fail safe" (specific regulations require "fail safe" features).
- A manually reset cumulative timing device should be used to indicate an elapsed time and to turn off the machine when the total exposure reaches the planned amount.
- Some machines such as analytical x-ray devices, irradiators and accelerators have individual safety programs. These detailed operating and emergency procedures must be posted and followed.
- Proper maintenance on all radiation producing equipment is essential. Only properly trained technical staff should perform all repairs to these instruments.

3.5 Radiation and Contamination Surveys

Prevention of the spread of contamination and excessive radiation exposure is the responsibility of the Authorized User who is also responsible for providing radiation detection equipment to monitor removable contamination and external radiation exposure levels as appropriate. Radiation detection devices, such as liquid scintillation counters, gamma counters, and portable survey instruments, must be available.

3.5.1 Laboratory Surveys

"Survey" means an evaluation of the radiation hazards incident to the use, release, disposal and presence of radioactive materials and other sources under a specific Authorized User. A survey should include measurements of external radiation levels near sources in use, storage, waste containers, etc. and of removable contamination by wipe testing. Both restricted (areas posted with radiation warning signs and labels) and adjacent unrestricted areas should be included. Surveys should also include an examination of the presence and condition of the warning signs, instructions and other necessary postings and a thorough review of the records-keeping system. During the monthly survey, records-keeping systems and the Radiation Safety Notebook should be reviewed for completeness and orderliness. Waste storage, records and security should be examined also during the monthly survey.

3.5.2 HS Surveys

HS personnel periodically inspect the laboratories of the Authorized Users to monitor the in-lab radiation safety program. The radiation exposure rates and removable contamination levels are measured and records-keeping systems are reviewed during the surveys. The frequency of surveys is determined by the quantity of radioactive materials used, results of previous surveys, and general compliance with State and University HS regulations and policies. Although the HS inspections fulfill a need for a supervisory overview, they do not provide adequate day-to-day information regarding the effectiveness of radiation control procedures used in the laboratory. Therefore, laboratory personnel must routinely monitor their laboratories when using radiation sources.

3.5.3 Authorized User Surveys

Each Authorized User is required to conduct formal, documented surveys on a regular basis in every authorized radiation use space. The HS establishes this survey schedule during the application review. The typical schedule *requires the survey to be performed within each* calendar month. The schedule is subject to change through the HS in accordance with the frequency of source use, potential for exposure and the established safety record.

When higher energy beta emitters, such as P-32, or gamma emitters, such as I-125, Na-22, etc. are used in the laboratory, the monthly Authorized User survey must consist of a wipe test and instrument survey using a portable, handheld survey meter. The instrument make, model

number, serial number, calibration date, and readings must be recorded on the written survey report. Instrument surveys are specified in the radiation source authorization, if required. *Wipe test* surveys only are required when lower energy beta emitters, such as H-3, C-14, or S-35, or small quantities of gamma emitters, such as that contained in commercial test kits, are used in the laboratory.

During the monthly Authorized User survey, records-keeping systems and the Radiation Safety Notebook should be evaluated for completeness and orderliness. Waste storage, records, security, and the overall laboratory radiation safety program should also be reviewed. If no radioactive material has been used during a month, a statement of that fact may be entered into the Radiation Safety records in lieu of a recorded survey. *However, a* record of the survey performed after the last use must be on file, showing that all radiation and contamination levels are within the specified guideline limits. For Authorized Users having more than one room authorized on their radiation us license, a statement of "No Use" may be entered for the individual rooms where radioactive materials was neither used nor stored (including waste) for the month. As such, a survey is required only in those rooms where use or storage occurred during the calendar month. The HS may, according to particular conditions including quantities or types of materials and an Authorized User's safety record, set radiation safety survey schedules specifically designed for named laboratories or Authorized Users.

3.5.4 Instrument Surveys

The routine use of radiation survey instruments during the course of any work utilizing gamma or higher energy beta emitters (other than H-3, C-14, S-35, etc.) is required. After each use of stock solutions:

- Monitor hands, arms, front of lab coat and other potentially contaminated areas.
- Monitor bench tops, floor areas, equipment, etc.
- Monitor hands and clothing before leaving the laboratory.

Do not use a survey meter that has not been calibrated within the past year for any purpose. Never use a survey meter that indicates “low batteries”. Any meter that is not operating properly or is out of calibration must be tagged or labeled as "Out-Of-Service". Low batteries should be replaced at once. If an instrument is to be kept in storage, the batteries should be removed. Old or spent batteries are prone to leakage and can ruin the instrument.

3.5.5 Wipe Tests

Wipe tests are performed by wiping a filter paper disk, Q-tip, etc., across the areas of interest and then determining the activity in a counter calibrated for the suspected radionuclide. Wipe tests are more sensitive than instrument surveys and should especially be used when instrument surveys indicate possible contamination. They are the only practical method of monitoring weakly penetrating beta emitters, such as H-3, C-14, S-35 and are to be substituted for instrument surveys for such emitters. *The wipe test method must* be used for all surveys conducted for identifying and/or documenting removable contamination levels.

When the radioactive contaminations are above the action levels, clean and decontaminate the area. Re-survey with wipe tests and record the results to document adequate cleanup.

3.5.6 Action Levels

3.5.6.1 External Radiation

Radiation levels must be kept to less than 2 mrem/hr at 30 cm (12 in) from the source surface and to levels as low as reasonably achievable.

Areas in which the radiation exposure level exceeds 5 mrem/ hr must be designated as a the "Radiation Area" and posted with an appropriate sign. When such levels are expected, the HS will indicate specific procedures to be followed when the "authorization" allows the use radioactive materials is issued. When such conditions arise that are not covered by the authorization, the HS must be contacted immediately.

3.5.6.2 Contamination

HS records of removable contamination levels, in terms of disintegrations per minute (DPM), per 100 square centimeters, (standard areas to be covered by a "wipe").

Wipe test survey results by Authorized Users must also be recorded in DPM. Counting efficiencies used to convert from CPM to DPM may be stated in the Authorized User's records in lieu of converting to DPM. Typical liquid scintillation counting efficiencies are 20 percent for H-3 and 50 percent for other radionuclides. Laboratories may use the same counting efficiencies for wipes or use their own established efficiencies.

Actions to be taken as a function of contamination level are:

Contamination Level, DPM	Action
Below 600 DPM	• Record actual measurement for formal survey. • Cleanup recommended to as low as practicable levels. • No safety variance
600 DPM and Above	• Record actual measurement for formal survey. • Cleanup to less than 600 DPM is required, and as far below as practicable is recommended. • Record actual measurement after cleanup for formal survey. • Citation for safety variance
Below 2000 DPM	• Record actual measurement for the survey formal. • Cleanup to as low as practicable levels. • No safety variance.
2000 DPM and Above	• Record actual measurement for the formal survey. • Cleanup to less than 2000 DPM is required, and as far below as practically recommended. • Record the actual measurements after the cleanup for formal survey. • Citation for safety variance
Below 15000 DPM	• Record the actual measurement for the formal survey. • Cleanup to as low as practicable levels. • No safety variance.
15000 DPM and Above	• Record the actual measurement for formal survey. • Cleanup to less than 15000 DPM is required, and as far below as practically recommended. • Record the actual measurement after cleanup for formal survey. • Citation for safety variance

3.5.7 Training

Refer to *QU* ***HSMS Section 11.0 Training and Competency*** for the required trainings for personnel potentially exposed to radiation risk.

3.5.8 Survey Instrument Calibration

Survey instruments must be annually calibrated. The calibrations will be performed by the HSS. The HSS must be informed whenever a new instrument is purchased, after significant repair or other calibration has been done.

3.5.9 Removal of Laboratory Equipment

Any equipment in the laboratory which could have been contaminated with radioactive material must be surveyed before removal to another laboratory, transfer to a repair shop, or transfer to Surplus Property. Before the equipment is transferred and following a satisfactory survey, all warning signs and stickers must be removed. A Safety Clearance from HSS must also be completed.

3.5.10 Vacating Laboratory Spaces

HSS must be informed of all the changes in authorized laboratory spaces, including transfers or departures from the University and laboratory relocations. Written notification to HSS is required prior to vacating a laboratory or moving into different labs. The Authorized User is responsible for surveying all the spaces and equipment and proper removal of all radioactive waste and radioactive sources prior to the changes. Upon notification, via the filing of a Safety Clearance, HS will complete a final clearance survey of the authorized spaces.

3.6 Personnel Monitoring – External Exposure

The personnel monitoring devices (whole body dosimeters, extremity dosimeters, pocket dosimeters, etc.) are provided by the HS to measure an individual's radiation exposure to gamma, energetic beta and x-ray sources. The standard monitoring device is issued as a clip-on badge or ring badge bearing the individual assignee's name, date of the monitoring period and a unique identification number. The dosimeters are provided, processed and reported through a commercial service company that meets the current requirements of the State of Qatar.

3.6.1 Requirements

Radiation protection state regulations and Qatar University policy require that appropriate personnel monitoring equipment must be provided to the individuals who:

- Are likely to receive a radiation dose in any calendar quarter in excess of 10 percent of:
  - 5 rems, total effective dose equivalent, to the whole body.
  - 15 rems, eye dose equivalent, to the lenses of the eyes.
  - 50 rems, shallow dose equivalent, to the skin or to each of the extremities.
- Are less than 18 years of age and are likely to receive a radiation dose in any calendar year in excess of 10 percent of:
  - 0.5 rems to the whole body.
  - 1.5 rems to the lenses of the eyes.
  - 5 rems to the skin or to each of the extremities.
- Have declared a pregnancy or planned pregnancy.
- Enter a High or Very High Radiation Area (exposure to greater than 100 millirems in any one hour).
- Operate analytical x-ray devices (both monthly ring and whole body badges required).
- Meet the issuance criteria as assessed by the HSS.

3.6.2 Issuance Criteria

Authorized Users must file a Lab / Radiation Worker Registration, for each individual who may work with radiation sources. This provides for the basic information regarding training and experience and the personnel monitoring needs. Initial personnel monitoring decisions will be based on this information. Further evaluations, and reevaluations, will be made through radiation staff registration updates, application reviews, personnel monitoring reports, high dose of investigations, surveys and individual interviews by the responsible HS.

In general, the personnel monitoring devices will be exchanged monthly for individuals needing personnel monitoring as specified in the requirements section, above.

The personnel monitoring these devices may be exchanged quarterly when less frequent and/or smaller exposures are anticipated. The personnel monitoring devices will not normally be issued to individuals who work solely with low energy beta emitters such as H-3, C-14 and S-35 or very small quantities of radioactive material such as I-125 in-vitro kits.

3.6.3 Monitoring Protocol

Radiation in the restricted area under such conditions when an occupational radiation dose is in excess of 10 percent of the specified calendar year limits may occur. HS will request prior radiation dose histories from all the past employers.

Dosimeters will be exchanged on a monthly or quarterly basis depending on the anticipated exposure level as evaluated by the HSS.

All the personnel's occupational radiation dose records shall be maintained by the HS.

It shall be the responsibility of each individual dosimeter recipient to wear and use the dosimeter (s) properly.

Authorized Users are responsible for assuring that their radiation workers are wearing badges appropriately and that badges are returned on time.

3.6.4 Other Personnel Monitoring Devices

HSS may require the use of pocket dosimeters, ring dosimeter, or other monitoring devices when particular procedures are in operation.

3.6.5 Recording Exposures

The personnel measured the occupational radiation doses, including bioassay results, are to be recorded and maintained on file by HSS.

3.6.6 Use of Personnel Monitoring Devices

The whole body dosimeter (or other device) is to be worn on the body where it will most likely approximate the radiation exposure to the wearer's head and torso of. A dosimeter assigned for whole body monitoring is not to be used to monitor the extremities (hands, forearms, feet, ankles). Separate badges must be assigned for extremity monitoring. Generally, whole body dosimeters are to be worn between the waist and the neck. When a protective apron is worn, the badge is to be worn at the collar, outside the apron. In some circumstances, where exposure of the neck and lenses of the eyes are negligible, the monitoring badge may appropriately be worn under the apron. The HSS should be consulted for advice in these circumstances.

Extremity monitoring dosimeters (rings) are available in large or small sizes and for the right or left hand. Ring dosimeters should be worn whenever working with applicable sources. When using radioactive materials, the ring monitor element (label area) should be turned toward the palm. Gloves should be worn over the ring badge when contamination is possible.

3.6.7 Personnel Monitoring Reports

The occupational radiation dose reports are sent to each representative of the radiation staff groups. The report(s) must be posted or otherwise provided such that each group member may learn of his/her own dose record. Routine monitoring periods are currently monthly or quarterly. Each report will include the name, monitoring period date, dose (millirems) for the immediate past period, current calendar quarter, calendar year and the lifetime dose for each member of the group.

3.7 Personnel Monitoring - Internal Exposure

3.7.1 Bioassay Personnel Monitoring

Bioassay is the determination of the kind, quantity or concentration, and location of radioactive material in the human body by direct (in vivo) measurement or by analysis (in vitro) of materials excreted from the body. Commonly employed bioassay techniques include urinalysis and thyroid monitoring. A bioassay program provides the necessary personnel monitoring to measure operational or accidental uptakes by radiation workers. Radioactive material usage is approved only when the associated safety program, equipment, facilities and staff experience assures that safe use will be routinely maintained. The potential for the radiation exposure due to inadvertent failures of procedures and equipment may increase, however, when certain combinations of radionuclides, chemical or physical forms and activities are involved.

The current health physics practices and safety survey results provide evidence that a few, if any, radioactive material procedures currently in use allow routes for personnel uptakes. Some procedures do incorporate radionuclide form and activity combinations which warrant bioassay monitoring to assure that designated precautions remain effective.

A determination of bioassay personnel monitoring needs and frequency is made by the HS during the review of applications. The status of existing usage programs is periodically reviewed through radiation worker registrations, surveys, inventory records and a semiannual verification of the radiation staff and radionuclide stick to the limits. Routine bioassay monitoring will be conducted when any individual is working with radionuclide form/activity combinations exceeding established limits. "Working with" includes withdrawing an aliquot from a stock supply which itself exceeds a limit, although the activity actually used is below the bioassay limit.

3.7.2 Bioassay Radionuclide, Form and Activity Limits

3.7.2.1 Tritium (H-3)

Urinalysis is required within 24 hours, if possible, but not later than 72 hours after working with 100 mill curies or more of tritium in any form.

3.7.2.2 Iodine (I-125, I-131)

An external thyroid bioassay by external counting is required within 24 hours, if possible, but not later than 72 hours after working with the following limits or greater:

- Processes in open room or bench with possible escape of iodine from the process vessels:
    - 1 mCi if volatile form.
    - 10 mCi if bound to nonvolatile agent.
- Processes with possible escape of iodine carried out within a fume hood of adequate design, face velocity, and performance reliability:
    - 10 mCi if volatile form.
    - 100 mCi if bound to nonvolatile agent
- Processes carried out within glove boxes, ordinarily closed, but with possible release of iodine from process and occasional exposure to contaminated box and box leakage:
    - 100 mCi if volatile form.
    - 1000 mCi if bound to nonvolatile agent

3.7.2.3 Other Radionuclides (C-14, P-32, S-35, Ca-45, Cr-51, etc.)

Urinalysis is required within 24 hours, if possible, but not later than 72 hours following potential ingestion, inhalation, or skin contamination of personnel. Additional urinalysis or external organ counting may be conducted, depending on the biological attributes of a specific radionuclide.

3.7.2.4 Analysis and Record-keeping

Any staff request for a bioassay analysis will be honored. Pregnant radiation workers using radioactive materials will be placed on a mandatory monthly bioassay schedule. Standard methods for bioassay evaluations are normally sufficient to measure body or organ uptakes of radionuclides to a small fraction of an Annual Limit on Intake (ALI). An outside laboratory specializing in bioassay services will be used for any analysis requiring extraordinary equipment or procedures. Internal dose results will be recorded, added to any external occupational dose, and maintained as part of the radiation worker's overall personnel monitoring history.

3.8 Investigation Levels

Specific procedures for responding to any occupational radiation dose, which exceeds Level I or Level II in the following table:

3.8.1 External Exposure

Part of Body	Investigation Level I (mill rems/monitoring period)	Investigation Level II (mill rems/monitoring period)
Whole body, head trunk, gonads or lenses of the eyes	**100**	**400**
Extremities: arm, elbow, forearm, hand, thigh, knee, leg, foot	**1000**	**3000**
Skin	**1000**	**3000**
Conceptus	**30**	**40**

When Level I doses are exceeded, the HS shall send a written description of the dose report statistics, including the dose history for the previous two monitoring periods, to the person involved with a copy to the Authorized User. The individual will be requested to review his or her radiation safety procedures and work habits in an effort to maintain all the doses as low as reasonably achievable. Radiation safety reviews and consultation are offered.

When Level II doses are exceeded, the HS shall conduct a direct investigation of the situation, including an interview with the person involved. A written investigation report shall be made, including dose trends over the past one year (as available) for that person. The person involved is provided with a copy of the report to review and sign. The conclusions drawn from the investigation provide a basis for confirming or modifying the dose and for establishing corrective actions to be taken.

If a regulatory overexposure occurs, the required reports will be filed with the Ministry of Environment.

3.8.2 Internal Exposure

Part of Body	Investigation Level I (mill rems/monitoring period)	Investigation Level II (mill rems/monitoring period)
Whole body*	**100**	**400**
Individual organs*	**1000**	**3000**

* Committed Effective Dose Equivalent (CEDE)

** Effective Dose Equivalent

When a Level I dose is exceeded, the HS will send a written description of the dose report, including the occupational dose history for the previous two monitoring periods, as available, to the person involved and to the Authorized User. The individual will be requested to review his or her radiation safety procedures and work habits in an effort to maintain all doses as low as possible. Radiation safety reviews and consultations will be considered.

When a Level II dose is exceeded, the HS will conduct a direct investigation of the situation, including an interview with the person involved. A written investigation report will be made, including the total dose trends over the past 12 months (as available) for that person. The person involved will be provided with a copy of the report to review and sign. Conclusions drawn from the investigation will be used as a basis for confirming or modifying the dose value and for establishing any corrective actions to be taken.

Any confirmed internal dose of 10 millirems or more will be recorded in the relevant individual's permanent occupational radiation personnel dose record. When the individual is also being monitored for external occupational radiation dose, the internal dose and external Deep Dose Equivalent will be summed and recorded on the permanent external dose record as the Total Effective Dose Equivalent.

Whenever any regulatory radiation overexposure occurs, the required reports will be filed with the Ministry of Environment by the HS.

3.9 Records

Under the terms of the University's authorizations to use radiation sources, the HS is in charge of maintaining portal-to-portal surveillance of all radiation sources on the campus. In order to facilitate this surveillance and to ensure that a high awareness of the rules and regulations governing the safe use of radiation sources is maintained, it is required that certain records and reference materials be maintained. These records and reference materials are the responsibility of the Authorized User, who is required to keep the material current and to make it readily available to laboratory workers and the HS. It is recommended that a notebook be maintained with the required information.

These records and references include, but are not limited to, the following:

- The University's current Radiation Laboratory Safety Policy. All other versions must be discarded.
- Copies of the Authorized User's License and Application to Use Radiation Sources). All license amendments must be maintained.
- Radioactive Materials Inventory Record forms.
- Monthly Radioactive Material Inventory Records
- Radiation and contamination surveys performed by the Authorized User and HS.
- Radioactive Waste Disposal records.
- Lab / Radiation Worker Registration forms.

Refer to ***QU HSMS Section 16.0 Document Control & Retention***.

3.10 Radiation Emergency Preparedness and Response

The Emergency Management procedures can be found in ***QU HSMS Section 8.0 Emergency Management*****.** However, further emergency requirements concerning radiation safety are detailed below.

3.10.1 Operator Minor Injury and No Overexposure

- Cease all operations.
- Check the dosimeter reading of the Radiation Workers.
- Check the radiation intensity with the survey meters.
- Call HS, 4403 3581.
- Call QU Medical 4403 3294/ 4403 5050.
- Call Hamad Hospital Emergency, if necessary, 4439 2111.

3.10.2 Suspected Overexposure

- Stop all operations.
- Check the dosimeter reading of the Radiation Workers.
- Check the radiation intensity with the survey meters.
- Prevent access to the surrounding area.
- Place lead shots and lead sheets over the suspected areas.
- Check the dose rate barriers.
- Call for additional help:
    - To assist in maintaining the integrity of the barriers.
    - To make necessary phone calls.
- Call HS, 4403 3546 or 4403 3593 or 4403 3999
- Record names and location of any personnel involve in the incident.
- Call Hamad Hospital Emergency, 4439 2111. Send immediately suspected overexposure radiation workers for medical examination.
- Inform Ministry of Environment at telephone number 4420 7777.
- Take appropriate action, depending on the severity of the exposure.

3.10.3 Lost Source

- Stop all operation.
- Check the dosimeter reading of the radiation workers.
- Check the radiation intensity with the survey meters.
- Prevent access to the surrounding area.
- Place lead shots and lead sheets over suspected area.
- Check the dose rate at the barriers.
- Call for additional help:
    - To assist in maintaining the integrity of the barriers.
    - To make necessary phone calls.
- Call the HS, 4403 3581.
- Record names and location of any personnel involved in the incident.
- Call Hamad Hospital Emergency, 4439 2111. Send immediately suspected overexposure radiation workers for medical examination.
- Inform Ministry of Environment at telephone number 4420 7777.
- Take appropriate action, depending on the severity of the exposure.
- If the source is known to be in projector, then visual search at last known whereabouts, otherwise the lost source shall be treated as unshielded.
- Hold sealed source to be separated from the projector, then a search using survey meters and personal monitoring devices shall be undertaken again starting at the last known whereabouts.
- Survey meter should be on the lowest reading scale until nearing source, taking care with regard to persona; care.
- Once located, the HSS shall decide on the course of action to be taken for recovery.

3.10.4 Stuck, Damaged or Unshielded Source

- Stop all operations.
- Check the dosimeter reading of the radiation workers.
- Check the radiation intensity with the survey meters.
- Prevent access to the surrounding area.
- Place lead shots and lead sheets over suspected area.
- Check the dose rate at the barriers.
- Call for additional help:
    - To assist in maintaining the integrity of the barriers.
    - To make necessary phone calls.
- Call HS, 4403 3581.
- Record names and location of any personnel involve in the incident.
- Call Hamad Hospital Emergency, 4439 2111. Send immediately suspected overexposure radiation workers for medical examination.
- Inform Ministry of Environment at telephone number 4420 7777.
- Take appropriate action, depending on the severity of the exposure.
- If the source is known to be in the projector, then the visual search at last known whereabouts, otherwise lost source shall be treated as unshielded.
- Should sealed source be separated from projector, then a search using survey meters and personal monitoring devices shall be undertaken again starting at the last known whereabouts.
- Survey meter should be on the lowest reading scale until nearing source, taking care with regard to personal care.
- Once located, the HSS shall decide on the course of action to be taken for recovery based on calculated dose rates, shielding, time, location and other factors.
- HS shall then take necessary steps to recover the source with the help of lead apron, tongs, cutters, and lead pot and render the safe area.

3.10.5 Stolen Source

- Check the source in the storage pit and the source at all sites and verify the content of the inventory of sources.
- When it is confirmed the source is missing or stolen, inform the HS.
- Take appropriate actions in collaboration with Ministry of Environment.

3.10.6 Fire

- Cease all operations.
- Follow fire emergency preparedness and response.
- Call the HS Fire & Emergency Management Section, 4403 3999
- Check the dosimeter reading of the radiation workers.
- Check the radiation intensity with the survey meters.
- Prevent access to the surrounding area.
- Check the dose rate at the barriers.
- Call for additional help:
    - To assist in maintaining the integrity of the barriers.
    - To make necessary phone calls.
- Record names and location of any personnel involve in the incident.
- Send immediately suspected overexposure radiation workers for medical examination.

3.10.7 Suspected Contamination

- Stop all operations.
    - Check dosimeter reading of the radiation workers.
    - Check the radiation intensity with the survey meters.
    - Prevent access to the surrounding area.
    - Call for additional help:
        - To assist in maintaining the integrity of the barriers.
        - To make necessary phone calls.
    - Call the HSS, 4403 3560 or 4403 3546 or 4403 3593
    - Record the names and locations of any personnel involved in the incident.
    - Send immediately the workers suspected of experiencing overexposure of radiation for medical examination.
    - Inform Ministry of Environment at telephone number 4420 7777.

3.10.8 Post Incident / Accident Procedure

- The incident/accident should be reported to the appropriate authorities.
- All classified and non-classified personnel, f exposed in excess of their dose limits, shall be sent for medical examination.
- The Ministry of Environment should be notified.
- All apparatus must be checked for defects and, if necessary, repaired before it is re-used.
- Thermo Luminescent Dosimeter (TLD's) of affected personnel shall be sent to Ministry of Environment for investigation.
- All emergency and incident/ accident, no matter how small, shall be investigated by the HSS and keep a written record.
- HSS shall submit a report to the Laboratory and the User, giving recommendations to prevent recurrence.

4 Document Control

This Technical Guideline is a controlled document. The controlled version of this guideline is located on the QU Electronic Documentation Management System.

Any printed copies of this controlled document are reference copies only. It is the responsibility of all of those with printed copies to ensure their copy is kept up to date.

Refer to ***QU HSMS Section 16.0 – Document Control and Record Retention***.

Appendix - A
Radiation Units.

Appendix - A
Radiation UNITS

Roentgen: Is the measurement of energy produced by Gamma or X-Ray radiation in a cubic centimeter of air. It is abbreviated with the capital "R". One milliroentgen, abbreviated "mR" is one-thousandth of a roentgen. One microroentgen, abbreviated “uR” is one-millionth of a roentgen.

RAD: Radiation Absorbed Dose. Original measuring unit for expressing the absorption of all types of ionizing radiation (alpha, beta, gamma, neutrons, etc) into any medium. One rad is equivalent to the absorption of 100 ergs of energy per gram of absorbing tissue.

REM: Roentgen Equivalent Man is a measurement that correlates the dose of any radiation to the biological effect of that radiation. Since not all radiation has the same biological effect, the dosage is multiplied by a "quality factor" (Q). For example, a person receiving a dosage of gamma radiation will suffer much less damage than a person receiving the same dosage from alpha particles, by a factor of three. So alpha particles will cause three times more damage than gamma rays. Therefore, alpha radiation has a quality factor of three. Following is the Q factor for a few radiation types.

Radiation:	**Quality Factor (Q)**
Beta, Gamma and X-rays	1
Thermal Neutrons	3
Fast n, a, and protons	10
Heavy and recoil nuclei	20

The difference between the rad and rem is that the rad is a measurement of the radiation absorbed by the material or tissue. The rem is a measurement of the biological effect of that absorbed radiation. For general purposes most physicists agree that the Roentgen, Rad and Rem may be considered equivalent.

System International (SI) Units
The System International (S.I. unit) units for radiation measurements are “gray” (Gy) and “sivert” (Sv) for absorbed dose and equivalent dose respectively.
The conversion from one system to another is simple:

1 Sv = 100 rem	1 rem = .01 Sv
1 mSv = 100 mR (mrem)	1 mR = .01 mSv
1 Gy = 100 rad	1 rad = .01 Gy
1mGy = 100 mrad	1 mrad = .01 mGy

How Much Radiation is Safe? In the United States the U.S. Nuclear Regulatory Commission (NRC) determines what radiation exposure level is considered safe. Occupational exposure for worker is limited to 5000 mrem per year. For the general population, the exposure is 500 mrem above background radiation in any one year. However for long term, multi-year exposure, 100 mrem above background radiation is the limit set per year. Let’s extrapolate the 100 mrem number to an hourly radiation

exposure rate. There are 365 days/yr x 24 hr/day equals 8760 hours. Divide 100 mrem by 8760 hours equals .0114 mrem/hr or 11.4/hr microrem. This is an extremely low radiation level. The background radiation in my lab hovers around 32 uR/hr. Am I in trouble? No. Typically background radiation in the United States averages 300 mrem/yr, or 34 microrem/hr. The NRC specifications is for radiation above this 34 urem/hr background radiation. Notice that my lab readings are in microrad (uR/hr) and the exposure limit is given in microrem (urem/hr). I do not know what type of radiation (a , b or y) the geiger counter is reading in my lab at any particular instant, so I do not know the Q factor of the radiation and therefore can not calculate the mrem. However for general purposes I consider them the one and the same. Remember the digital geiger counters are calibrated using a Cs-137 radioactive source.
Therefore the highest accuracy in reading radiation levels will be from Cs-137 sources.

Common Radiation Exposure (General Population)

Exposure Source	Dose(conventional)	Dose (SI)
Flight from LA to NY	1.5 mrem	.015 mSv
Dental X-ray	9 mrem	.09 mSv
Chest X-ray	10 mrem	0.1 mSv
Mammogram	70 mrem	0.7 mSv
Background Radiation	620 mrem/year	6.2 mSv/year

Background radiation consists of three sources ; **Cosmic** radiation from the sun and stars. **Terrestrial** radiation from low levels of uranium, thorium, and their decay products in the soil, air and water. **Internal** radiation from radioactive potassium-40, carbon-14, lead-210, and other isotopes found inside our bodies.

Digital Geiger Counters are extremely sensitive and will detect and measure background radiation in addition to detecting and measuring radioactivity above background radiation.